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(71) Applicant *(for all designated States except US)*: **METSO PAPER, INC.** [FI/FI]; Fabianinkatu 9 A, FI-00130 Helsinki (FI).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **POIKOLAINEN, Antti** [FI/FI]; Ritopohjantie 5 as 4, FI-40250 Jyväskylä (FI).

(74) Agent: **FORSSÉN & SALOMAA OY**; Lautatarhankatn 8B, FI-00580 Helsinki (FI).

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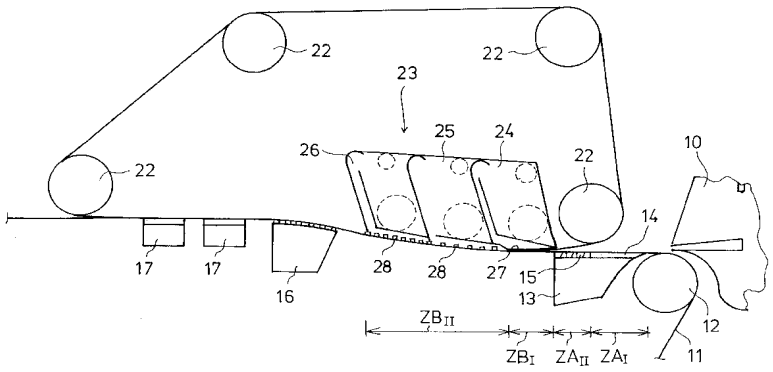
(54) **Title:** WEB-FORMING SECTION OF A PAPER OR BOARD MACHINE



(57) **Abstract:** A twin-wire former of a paper or board machine comprises a single-wire initial dewatering section and a twin-wire zone in which inside an upper- wire loop (21) there is a dewatering box (23) provided with a curved cover which guides the upper wire (21) into contact with a stock layer on a lower wire (11). In connection with the dewatering box (23), there is a first dewatering zone (ZB_{II}) in which the cover (27) of the dewatering box is designed so that it produces non-pulsating dewatering of the stock between the wires (11, 21) and a second dewatering zone (ZB_{II}) in which the cover of the dewatering box consists of cross-directional de watering blades (28) which produce pulsating dewatering of the stock between the wires (11, 21). At the area of the second dewatering zone (ZB_{II}), the upper wire (21) is supported against the dewatering blades (28), the lower wire (11) being unsupported. After the dewatering box (23) inside the lower wire loop (11), there is a forming shoe (16) provided with a curved cover before a transfer suction box (17).

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Web-forming section of a paper or board machine

The invention relates to a twin-wire web-forming section of a paper or board machine which comprises a single-wire initial dewatering section and a twin-wire zone in which inside an upper-wire loop there is a dewatering box provided with a curved cover which guides the upper wire into contact with a stock layer on a lower wire. In connection with the dewatering box, there is a first dewatering zone in which the cover of the dewatering box is designed so that it produces non-pulsating dewatering of the stock between the wires, and a successive second dewatering zone in which the cover of the dewatering box consists of cross-directional dewatering blades which produce pulsating dewatering of the stock between the wires.

In a twin-wire former provided with initial dewatering, stock is fed from the headbox onto the lower wire on which water is removed from it downwards, after which it is guided to the twin-wire zone in which water is removed from it both downwards through the lower wire and upwards through the upper wire. At the beginning of the twin-wire zone, the upper wire is brought into contact with the stock layer on the lower wire. The upper wire can be guided onto the stock layer by means of a forming roll provided with an open surface. Dewatering on the forming roll is substantially non-pulsating, but on the outlet side of the forming roll is created a strong underpressure pulse which can break the web in the worst case. Also are known arrangements in which the upper wire is guided from a breast roll directly to a pulsating dewatering zone so that the upper wire is unsupported when converging with the surface of the stock layer. In such a case, the adjustability of upwards dewatering is weak.

Pulsating dewatering is produced by dewatering blades which are arranged to support the wires cross-directionally in relation to their travel direction. When there are dewatering blades inside only one of the wire loops, the outer wire is

free to adjust itself when the thickness of the stock layer between the wires changes, and the magnitude of pressure pulses created by the dewatering blades remains substantially constant as the basis weight of paper or board changes. Alternatively, there can be dewatering blades inside both wire loops, whereby the direction of the pressure pulses and dewatering alternates. In order to make the magnitude of the pressure pulses remain constant, the dewatering blades of one side are usually adjustably loadable, whereby they are called loadable blades.

The use of dewatering blades and loadable blades intensifies dewatering and improves the formation of the web, because the pressure pulses create shear forces in the stock layer which break already formed flocs. On the other hand, the pressure pulses and the alternation of dewatering direction decrease retention as fines and fillers are washed away by water in the vicinity of the surface layers of the web. Effective pressure pulses increase the orientation of fibres and thus increase the strength difference between the machine- and cross-directions of paper. Blade dewatering also increases the wear and tear of wires. The thickness of the stock layer between the wires and the great variations of thickness set limits to the use of loadable blades, because of which loadable blades cannot always be used. Loadable blades typically impair bursting and interlaminar strengths which are extremely important to certain board grades. In order to maximise strength, one sometimes wishes to omit the blades or put them to a later stage.

Fig. 7 of WO 2004018768 shows an arrangement according to prior art in which at the beginning of a twin-wire zone inside an upper-wire loop there is a suction box in connection with which there are at least two successive dewatering zones. A first dewatering zone is constituted by a forming shoe having a curved cover against which the upper wire is supported, the lower wire being in the area of the forming shoe unsupported. The forming shoe has a substantially open surface and due to the effect of underpressure arranged in the shoe it produces substantially non-pulsating dewatering of the stock between the wires. A second dewatering zone is constituted by cross-directional dewatering blades inside the upper wire,

which blades are supported against the stock between the wires, together with the dewatering blades inside the lower wire, which blades can be adjustably loaded against the stock between the wires at the area of slots remaining between the fixed dewatering blades for producing pulsating dewatering of the stock in the second dewatering zone.

When the twin-wire zone begins with non-pulsating dewatering, it is possible to keep retention good, because a fibre network formed on the surface of the stock layer will retain fines and filler well in the following dewatering stages where dewatering pressure is pulsating. When manufacturing board having heavy basis weight or when using slowly draining pulps, a non-pulsating forming shoe at the beginning of the twin-wire zone cannot always remove so much water from the stock that the web could immediately after the forming shoe be transferred between the dewatering blades and the loadable blades without risks. If the stock layer is too thick or its consistency is too low, there is a risk that the web will not endure the strong pulsation of the loadable blade area but breaks.

It has been observed that by increasing the underpressure of the non-pulsating forming shoe the dewatering capacity can be increased to a certain limit, after which the dewatering capacity starts to decrease despite of the increase of underpressure. The decrease of dewatering is probably due to the fact that as underpressure increases the surface of the stock layer against the wire is thickened so that dewatering through the surface layer becomes difficult. Because of this, the effect of underpressure should be interrupted at intervals, whereby the thickness of the stock layer is partly restored and the pore structure of its surface opens up. Even relatively low pressure pulses are adequate to open the surface structure of the fibre network so that dewatering can be continued.

The object of the invention is to solve the above-described problems related to prior art.

The invention is characterised by what is presented in the characterising part of claim 1.

In a manner known as such, at the beginning of the twin-wire zone there is a first dewatering zone which produces non-pulsating dewatering and a second dewatering zone which produces pulsating dewatering. In the new arrangement, the second dewatering zone is constructed so that there are dewatering blades only inside the upper-wire loop, the lower wire being free of loadable blades, whereby the position of the lower wire can automatically change when the thickness of the stock layer between the wires changes. Furthermore, after a dewatering box before a transfer suction box, there is a forming shoe inside the lower wire provided with a curved cover which increases dewatering through the lower wire.

When only the upper wire is supported against dewatering blades and the lower wire is free of loadable blades, the second dewatering zone produces only gentle pulsation which is enough for opening the surface structure of the fibre network so that dewatering is able to continue also in the case in which the surface of the web has disadvantageously thickened in the previous dewatering zone.

In an embodiment of the invention, the dewatering box comprises three suction chambers of which the last one, i.e. the third suction chamber, is free of loadable blades inside the lower wire. At the area of the last suction chamber, the distance of blades in the machine direction is small, whereby relatively high underpressure can be used. Thus is produced high dewatering pressure without the wires diverging from each other.

In another embodiment of the invention, the dewatering box comprises four suction chambers, the third suction chamber of which is provided with dewatering blades and loadable blades inside the lower wire, because of which the third suction chamber produces clearly stronger pulsation than the second suction chamber. By means of the first and the second suction chamber, an adequate amount of

structural fibre network can be formed on the upper surface of the web before the loadable blades.

In an advantageous embodiment of the invention, the single-wire initial dewatering section begins on a forming board which comprises a first dewatering zone on which dewatering begins and a second dewatering zone which produces pulsating dewatering.

The initial dewatering section can be very short, whereby the twin-wire zone starts immediately after the forming board. Alternatively, the initial dewatering section can be longer, whereby it comprises one or more dewatering elements located inside the lower wire loop after the forming board before the beginning of the twin-wire zone.

The web-forming section according to the invention is especially suitable for manufacturing board and thick paper grades. It is also suitable for manufacturing multi-layer boards.

Because there is adequate dewatering capacity in the upper-wire unit, the length of the fourdrinier-wire section can be chosen so that the ratio of water volumes exiting upwards and downwards is 50/50. Then the layer purity of the web is good, because it is not necessary to remove water in more than one direction from each layer.

The invention will now be described with reference to the figures of the accompanying drawings, to the embodiments of which the invention is, however, by no means intended to be solely restricted.

Fig. 1 is a side view of a part of a web-forming section according to the invention.

Fig. 2 shows the development of dewatering in a non-pulsating forming shoe as a function of underpressure used.

Fig. 3 is a side view of a part of a web-forming section, the short initial dewatering section of which comprises a forming board which is provided with suction.

Fig. 4 is a side view of a part of a web-forming section according to another embodiment of the invention.

Fig. 5 shows a variation of the web-forming section of Fig. 4.

Fig. 6 shows another variation of the web-forming section of Fig. 4.

Fig. 7 shows the web-forming section applicable to manufacturing a board web as a whole.

Fig. 8 shows another web-forming section applicable to manufacturing a board web as a whole.

The web-forming section shown in Fig. 1 comprises a lower wire loop 11 which forms a single-wire initial dewatering section, and an upper-wire loop 21 which together with the lower wire 11 defines a twin-wire zone after which the web follows the lower wire 11. Stock is fed from a headbox 10 over a breast roll 12 to a fourdrinier-wire section of the lower wire 11 on which water is removed from the stock by means of dewatering elements (not shown in figures) located below the lower wire 11. The upper wire 21 forms a loop the travel of which is guided by guide rolls 22. Inside the upper-wire loop 21, there is a dewatering box 23 which guides the upper wire 21 onto the stock layer. At this stage, the upper surface of the stock layer consists of relatively dilute pulp, whereas its lower surface is couched into a fibre network against the lower wire 11.

The dewatering box 23 is provided with a curved cover and it comprises three successive suction chambers 24, 25, 26 which advantageously have different underpressures. By the effect of the suction chambers 24, 25, 26, into connection with the dewatering box 23 is constituted at least two successive dewatering zones ZB_I and ZB_{II} the first of which is non-pulsating and the second is pulsating. The first suction chamber 24 is provided with a cover structure 27 which produces non-pulsating dewatering of the stock between the wires 11, 21. The cover 27 has a large open surface area and, through holes in the cover, the first dewatering zone ZB_I is in contact with the underpressure prevailing in the suction chamber 24. It is characteristic of the structure of the cover 27 that uniform and elongated slots in the cross-machine direction have been avoided which would produce pulsating dewatering pressure. Cover structures producing non-pulsating dewatering are described e.g. in US 6372091 and WO 2004018768.

At the area of the second and third suction chamber 25, 26, the cover of the dewatering box 23 is constituted of dewatering blades 28 cross-directional in relation to the machine-direction which blades support the upper wire 21. Between the blades 28, there remain slots through which the second dewatering zone ZB_{II} is in connection with the underpressure prevailing in the suction chambers 25, 26. Inside the lower wire loop 11, there are no blades limiting or directing the travel of the lower wire 11, because of which the lower wire 11 can flexibly move in the height direction. Then, the distance between the wires 11 and 21 is directly dependent on the thickness of the stock layer between them. The dewatering blades 28 produce only gentle pressure pulses the magnitude of which is substantially constant irrespective of the thickness of the stock layer between the wires 11 and 21. The arrangement is extremely well applicable to manufacturing thick board grades. At the area of the third suction chamber 26, the dewatering blades 28 occur more densely and the underpressure is higher than at the area of the second suction chamber 25.

The dewatering box 23 is also followed by a forming shoe 16 located inside the lower wire loop 11 which shoe has a curved foil cover, and two suction boxes 17 the duty of which is both to remove water from the web and also to ensure that the web follows the lower wire 11 after the twin-wire zone.

Fig. 2 illustrates the development of dewatering on the area of the non-pulsating dewatering zone ZB_I as a function of underpressure in the suction chamber 24. The upper curve demonstrates desired dewatering and the lower curve demonstrates actual dewatering when the web is manufactured of difficultly draining pulps or with heavy basis weight. From the figure is seen that as suction increases, dewatering does not always increase as expected, but after a certain maximum value dewatering starts to decrease (slashed area). This is due to the fact that the surface of the web thickens due to the effect of underpressure, whereby dewatering through the dense surface layer becomes difficult. The thickening of the fibre network can be decreased by directing pressure pulses to it which have been produced by dewatering blades. To achieve this, in the web-forming unit according to the invention after a non-pulsating dewatering zone is arranged a pulsating dewatering zone in which the thickness of the stock layer is not limited by loadable blades.

Fig. 3 shows an alternative arrangement in which the twin-wire zone is preceded by a very short initial dewatering section. Initial dewatering takes place on a forming board 13 which is provided with underpressure and which comprises two successive dewatering zones ZA_I and ZA_{II}. Dewatering starts on the area of the first dewatering zone ZA_I and continues in the second dewatering zone ZA_{II} in which the cover of the forming board 13 is constituted of dewatering blades 15 cross-directional in relation to the machine direction which blades produce pulsating dewatering of the stock on the lower wire 11.

The dewatering box 23 corresponds the dewatering box 23 described in connection with Fig. 1, comprising a first non-pulsating dewatering zone ZB_I and a sec-

ond pulsating dewatering zone ZB_{II} which is further divided into two parts having different underpressures and blade densities.

The object is to produce already in the initial stage of dewatering a good filtering fibre layer on both surfaces of the web which layer lets water through but retains fines and filler. When the stock layer comes to the twin-wire zone, its lower surface is already couched into a fibre network, whereas on the upper surface there is still dilute stock. The first dewatering zone ZB_I of the twin-wire zone removes water effectively, whereby the fibre network is formed on the surface of the stock layer opposite the upper wire 21. In the first suction chamber 24, relatively low underpressure, e.g. 1–15 kPa, can be used. Underpressure in the second suction chamber 25 is advantageously 5–15 kPa and at its area the dewatering blades 28 are relatively scattered. Underpressure in the third suction chamber 26 is of the order of 20–25 kPa and the dewatering blades 28 are located more densely than at the area of the second suction chamber 25.

The length of the fourdrinier-wire section from the impact point of the slice jet of the headbox to the beginning of the twin-wire zone is advantageously less than 3 metres. Then, the consistency in the upper surface of stock suspension is low and the characteristics of the upper surface of the web can still be effectively affected in the twin-wire zone.

Fig. 4 shows another embodiment of the invention in which a dewatering box 123 has four chambers and there are also four different dewatering zones. The initial dewatering section is also here very short, comprising a forming board 13 after a first dewatering zone ZA_I of which there are some cross-directional dewatering blades 15 which produce a pulsating dewatering zone ZA_{II}.

The first dewatering zone ZB_I of the twin-wire zone comprises a first suction chamber 24 which is provided with a cover 27 which produces non-pulsating dewatering. The second dewatering zone ZB_{II} comprises a second suction chamber

25 which is provided with dewatering blades 28 at the area of which the lower wire 11 is unsupported. A third dewatering zone ZB_{III} comprises a third suction chamber 126 which is provided with dewatering blades 28 opposite to which there are dewatering blades 18 adjustable of their load and located inside the lower wire loop 11. Because of the dewatering blades 28 and the loadable blades 18, dewatering in the third dewatering zone ZB_{III} is strongly pulsating and its direction alternates. A fourth dewatering zone ZB_{IV} comprises a fourth suction chamber 127 at the area of which there are a set of dewatering blades 28 as the cover of the dewatering box 123 opposite which there are no loadable blades. Thus, dewatering in the fourth dewatering zone ZB_{IV} is less pulsating than in the third dewatering zone ZB_{III}. After the dewatering box 123, inside the lower wire loop 11 there is also a forming shoe 16 provided with a curved cover and a transfer suction box 17.

On the area of the first three dewatering zones ZB_{I}, ZB_{II} and ZB_{III}, the structure and characteristics of the web being formed can still be affected. At the area of the last dewatering zone ZB_{IV}, a completed fibre network has already been formed, because of which therein it is possible to affect mostly the effectiveness of dewatering and the dry content of the web after the twin-wire zone.

Locating the loadable blades 18 only at the area of the third suction chamber 126 makes it possible to produce such board grades which have heavy basis weight and in the manufacture of which difficultly draining pulps are used. The loadable blades considerably increase dewatering capacity, but simultaneously they decrease the bursting and interlaminar strength of board which are important characteristics with certain board grades, but with all grades these characteristics are not equally important. When pursuing good bursting and interlaminar strength, the arrangement of Fig. 3 is more advantageous than the arrangement of Fig. 4.

A web-forming section according to the invention is also applicable to manufacturing layered board and paper grades e.g. using a multi-layer headbox. Dewatering can be allocated to be done at a desired ratio through the upper and lower

wire. The arrangement gives a possibility to keep the characteristics of the different layers of board different better than earlier. This is a consequence of the possibility to arrange dewatering so that water from the lower surface is removed downwards and water from the upper surface upwards.

Fig. 5 shows a web-forming section corresponding Fig. 4 in which after the forming board 13 before the beginning of the twin-wire zone inside the lower wire 11 is arranged a suction box 19 which removes water from the stock through the lower wire 11 before it comes to the area of influence of the dewatering box 123.

Fig. 6 shows an arrangement corresponding Fig. 5 in which the distance between the forming board 13 and the forming shoe 19 is so large that a set of dewatering elements known as such, which elements are not described in detail in the figure, can be located there. This arrangement is advantageous when one desires to remove more water through the lower wire 11 before the twin-wire zone.

Fig. 7 shows a web-forming section corresponding Fig. 6 as a whole from a headbox 10 to a pick-up point. Stock is fed from the headbox 10 over a breast roll 12 to a forming board 13. The forming board 13 is followed by a set of suction boxes 30, 19 which remove water from the stock through a lower wire 11. When coming to the twin-wire zone, water is removed from the web by means of the dewatering box 123 which comprises four different dewatering zones, the first of which is non-pulsating and the following three are pulsating in different ways. Loadable blades 18 are arranged not until at the area of the third dewatering zone. After the twin-wire zone has ended, water is still removed from the web on the fourdrinier-wire section by means of suction boxes 31. After the fourdrinier-wire section, the web is transferred from the lower wire 11 by means of a pick-up roll 32 onto a fabric 33 of the press section.

Fig. 8 shows a web-forming section corresponding Fig. 4 as a whole from the headbox 10 to the pick-up point. Here the initial dewatering section is short com-

prising only a forming board 15 after which starts the twin-wire zone. As to its other parts, the arrangement corresponds the one described above in connection with Fig. 7.

Many different variations of the invention are possible within the scope defined by claims to presented next.

Claims

1. A twin-wire web-forming section of a paper or board machine, which comprises a single-wire initial dewatering section and a twin-wire zone in which there is a dewatering box (23, 123) inside an upper wire loop (21) provided with a curved cover which box guides the upper wire (21) into contact with a stock layer on a lower wire (11), in connection with which dewatering box (23, 123) there is a first dewatering zone (ZB_I) in which the cover (27) of the dewatering box is designed so that it produces non-pulsating dewatering of the stock between the wires (11, 21), and a successive second dewatering zone (ZB_{II}) in which the cover of the dewatering box is constituted of cross-directional dewatering blades (28) which produce pulsating dewatering of the stock between the wires (11, 21), **characterised** in that on the whole length of the second dewatering zone (ZB_{II}) the upper wire (21) is supported against the dewatering blades (28) the lower wire (11) being unsupported, and that after the dewatering box (23, 123) there is a forming shoe (16) inside the lower wire loop (11) provided with a curved cover before a transfer suction box (17).

2. A web-forming section according to claim 1, **characterised** in that the dewatering box (23) comprises three suction chambers (24, 25, 26), the first suction chamber (24) of which and its cover (27) constituting the first dewatering zone (ZB_I) and the second and the third suction chamber (25, 26) and the dewatering blades (28) as their cover constituting the second dewatering zone (ZB_{II}).

3. A web-forming section according to claim 1, **characterised** in that the dewatering box (123) comprises four suction chambers (24, 25, 126, 127), the first suction chamber (24) of which constitutes said first dewatering zone (ZB_I), the second suction chamber (25) constitutes said second dewatering zone (ZB_{II}), the third suction chamber (126) constitutes a third dewatering zone (ZB_{III}) at the area of which the upper wire (21) is supported against the dewatering blades (28) and there are loadable blades (18) guiding the travel of the lower wire (11), and the

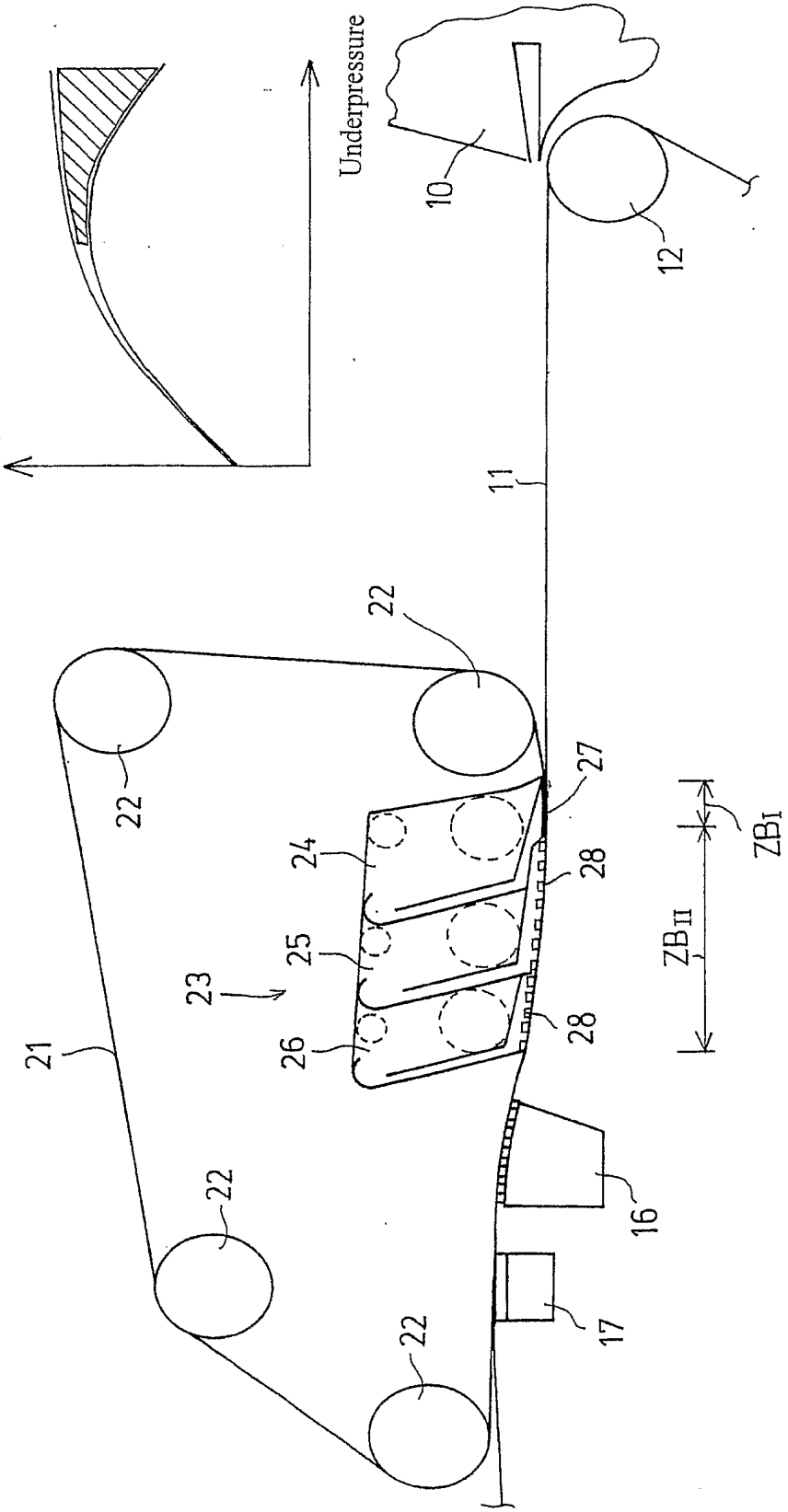
fourth suction chamber (127) constitutes a fourth dewatering zone (ZB_{IV}) at the area of which the upper wire (21) is supported against the dewatering blades (28), the lower wire (11) being unsupported.

4. A web-forming section according to any one of claims 1–3, **characterised** in that at the beginning of the single-wire initial dewatering section there is a forming board (15) which comprises a first dewatering zone (ZA_I) on the area of which dewatering is adjustable by means of underpressure, and a second dewatering zone (ZA_{II}) which produces pulsating dewatering of the stock on the lower wire (11).

5. A web-forming section according to claim 4, **characterised** in that the twin-wire zone begins immediately after the forming board (15).

6. A web-forming section according to claim 4, **characterised** in that after the forming board (15) before the twin-wire zone there is at least one dewatering element (19, 30).

FIG. 1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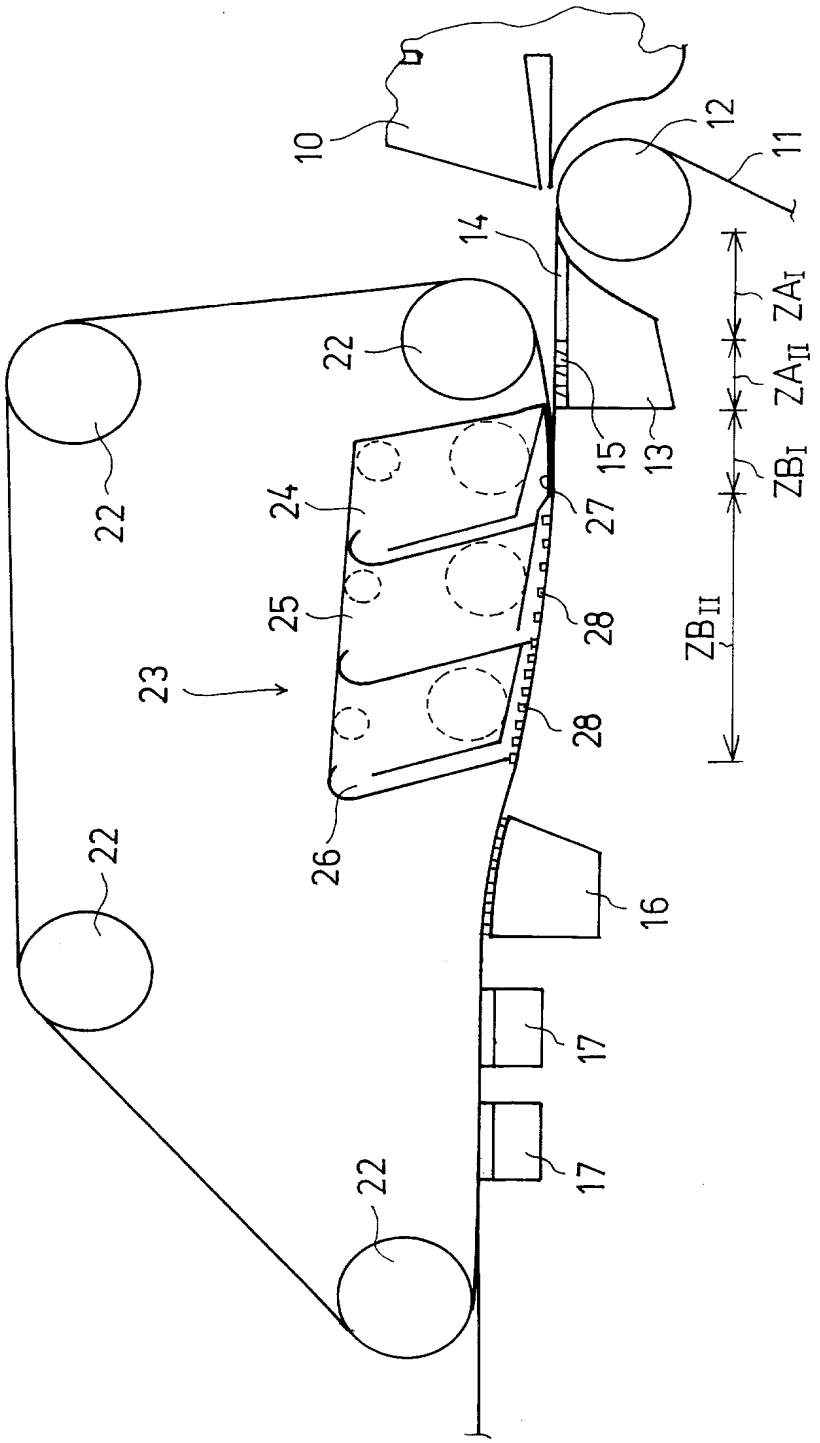
ZB I
ZB II

FIG. 2

Dewatering of forming shoe
Underpressure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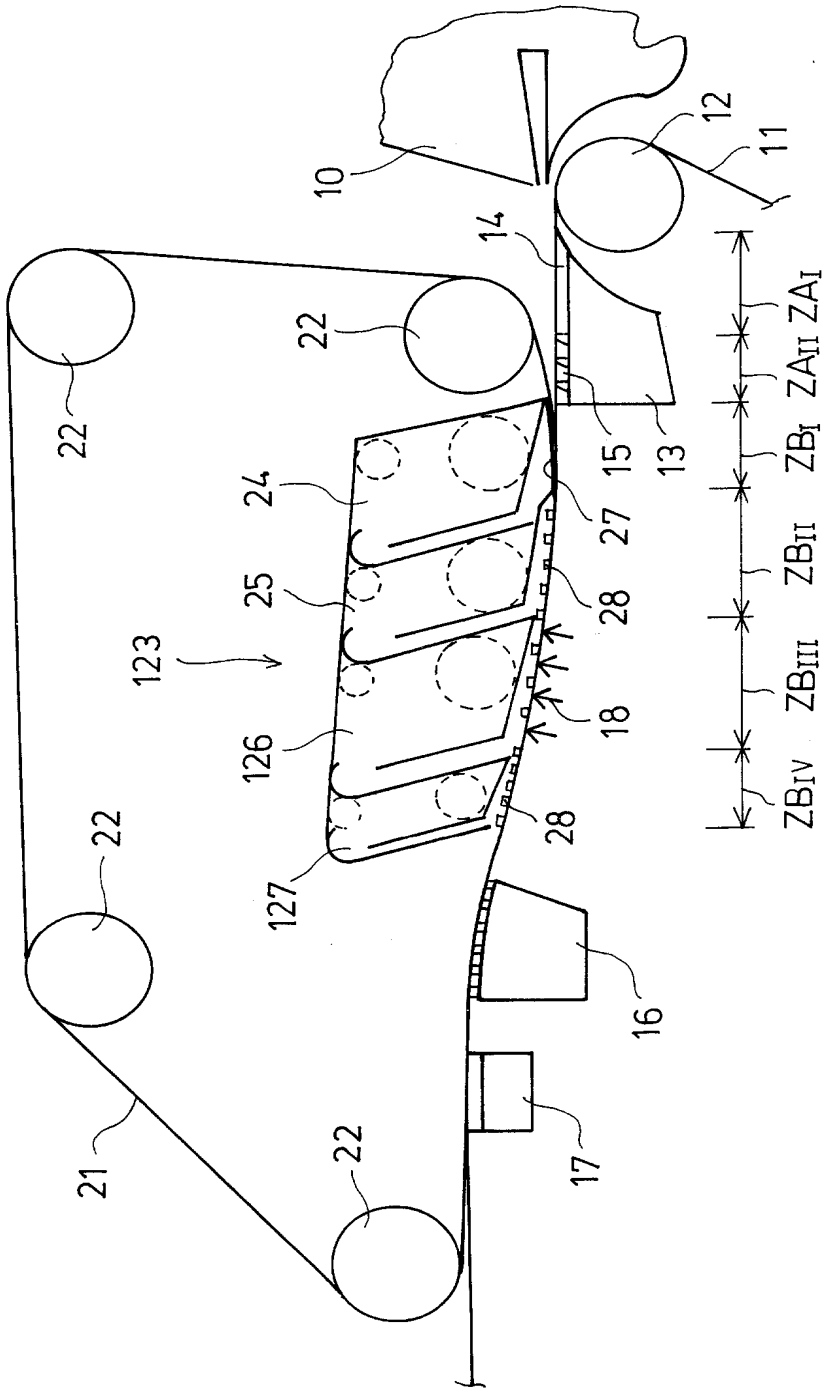
ZB_II

FIG.3

FIG. 4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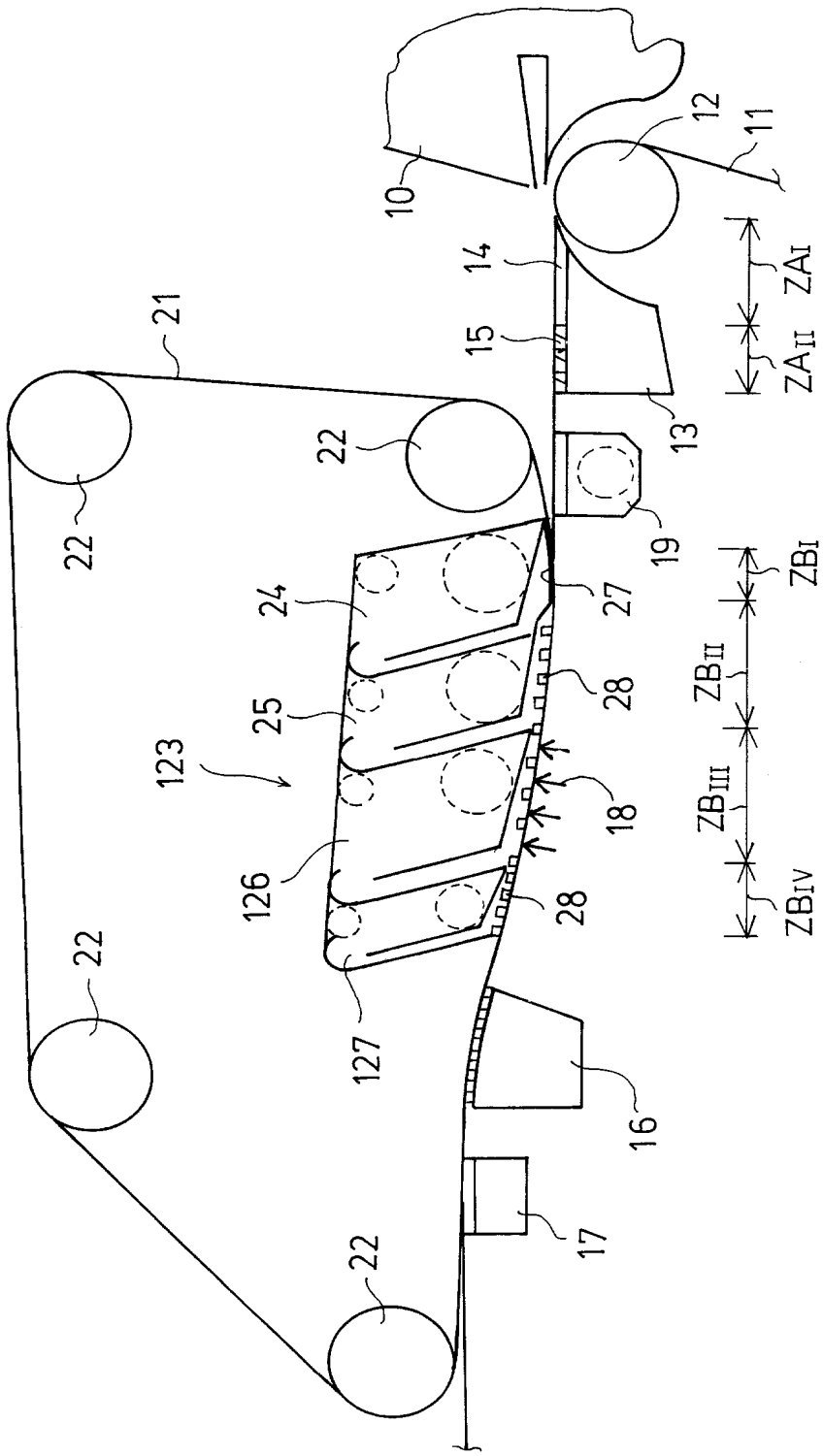
ZB_III
ZB_IV

FIG.5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ZAII
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ZBII
ZBIII
ZBIV

FIG.6

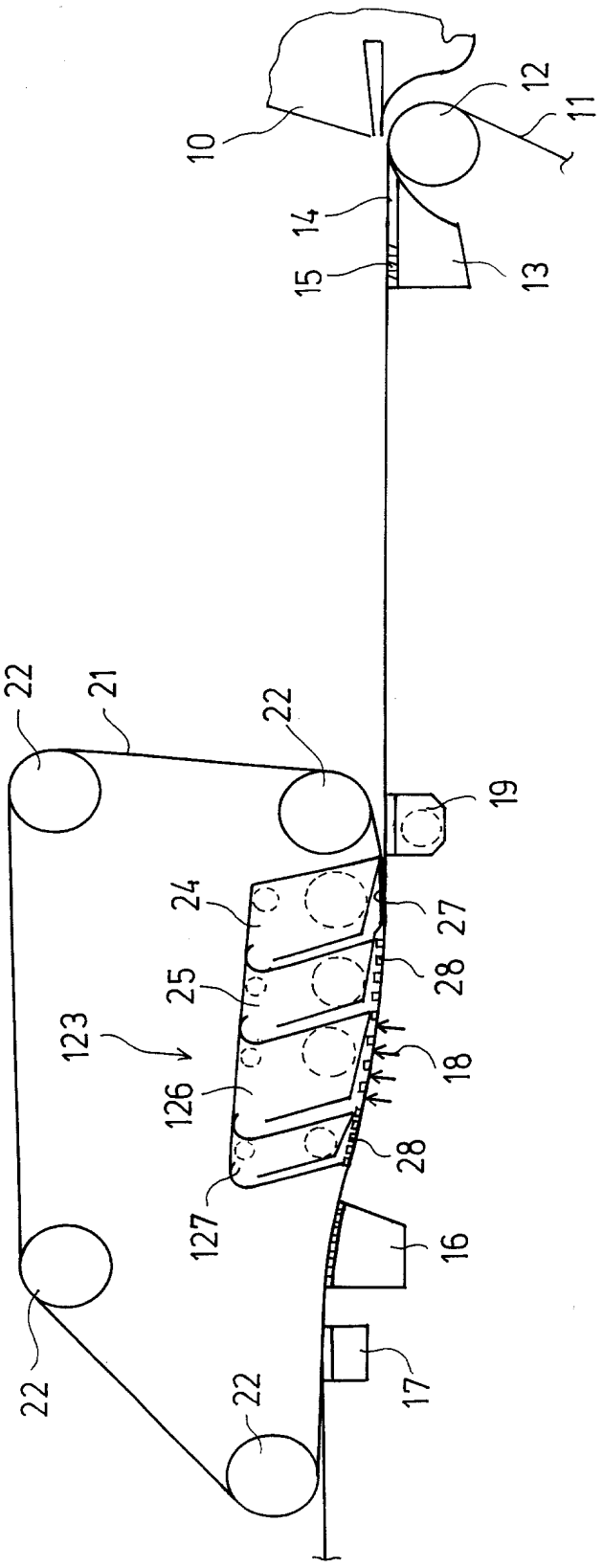


FIG.7

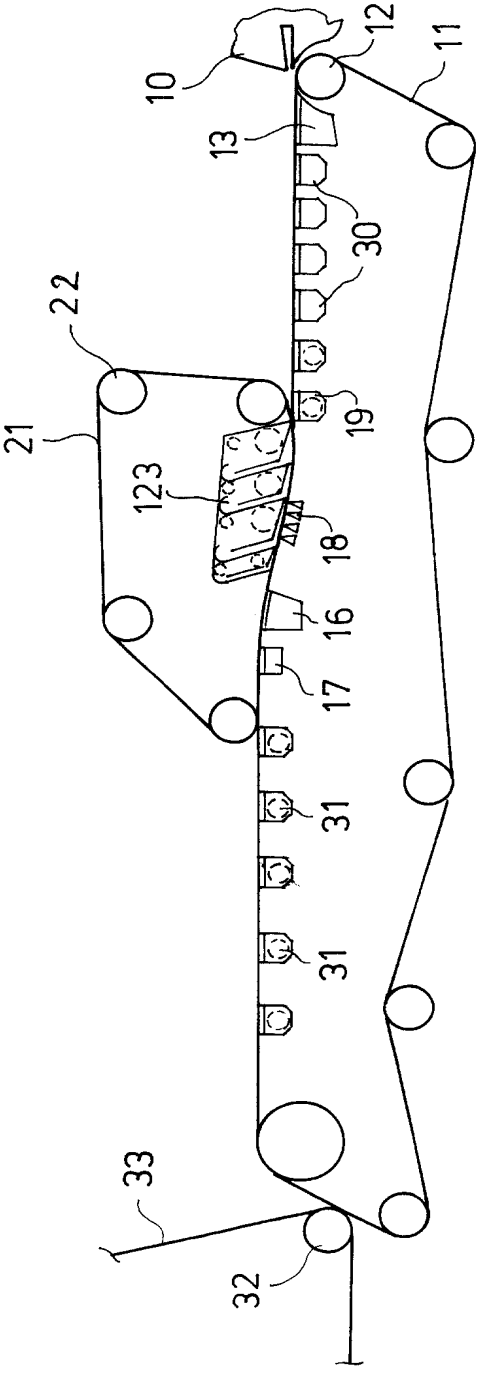
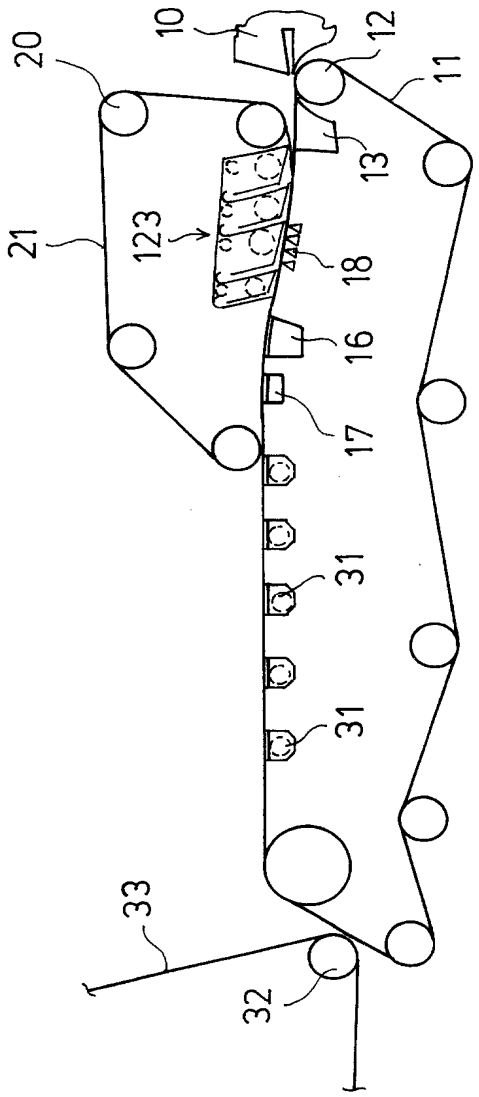


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2007/050083

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 8: D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2004018768 A1 (METSO PAPER INC et al.) 04 March 2004 (04.03.2004), Figure 7	1-6
Y	FI 944880 A (VALMET PAPER MACHINERY INC) 19 April 1996 (19.04.1996), Figure 2	1-6
A	US 5034098 A (HERGERT RICHARD E) 23 July 1991 (23.07.1991)	
A	FI 50648B B (VALMET OY) 02 February 1976 (02.02.1976)	

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 April 2007 (16.04.2007)	03 May 2007 (03.05.2007)

Name and mailing address of the ISA/FI	Authorized officer
National Board of Patents and Registration of Finland P.O. Box 1160, FI-00101 HELSINKI, Finland	Tuomo Pynnönen
Facsimile No. +358 9 6939 5328	Telephone No. +358 9 6939 500

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI2007/050083

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
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US 5034098 A	23/07/1991	KR 0161297B B1	18/02/1999
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		NO 142451B B	12/05/1980

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2007/050083

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.
D21F 1/00 (2006.01)
D21F 9/00 (2006.01)

PUB-NO: WO2007096467A1

DOCUMENT-IDENTIFIER: WO 2007096467 A1

TITLE: WEB-FORMING SECTION OF A PAPER OR BOARD MACHINE

PUBN-DATE: August 30, 2007

INVENTOR-INFORMATION:

NAME	COUNTRY
POIKOLAINEN, ANTTI	FI

ASSIGNEE-INFORMATION:

NAME	COUNTRY
METSO PAPER INC	FI
POIKOLAINEN ANTTI	FI

APPL-NO: FI2007050083

APPL-DATE: February 19, 2007

PRIORITY-DATA: FI20065122A (February 20, 2006)